UCRL-ID-131278

Mission

Annual Summary

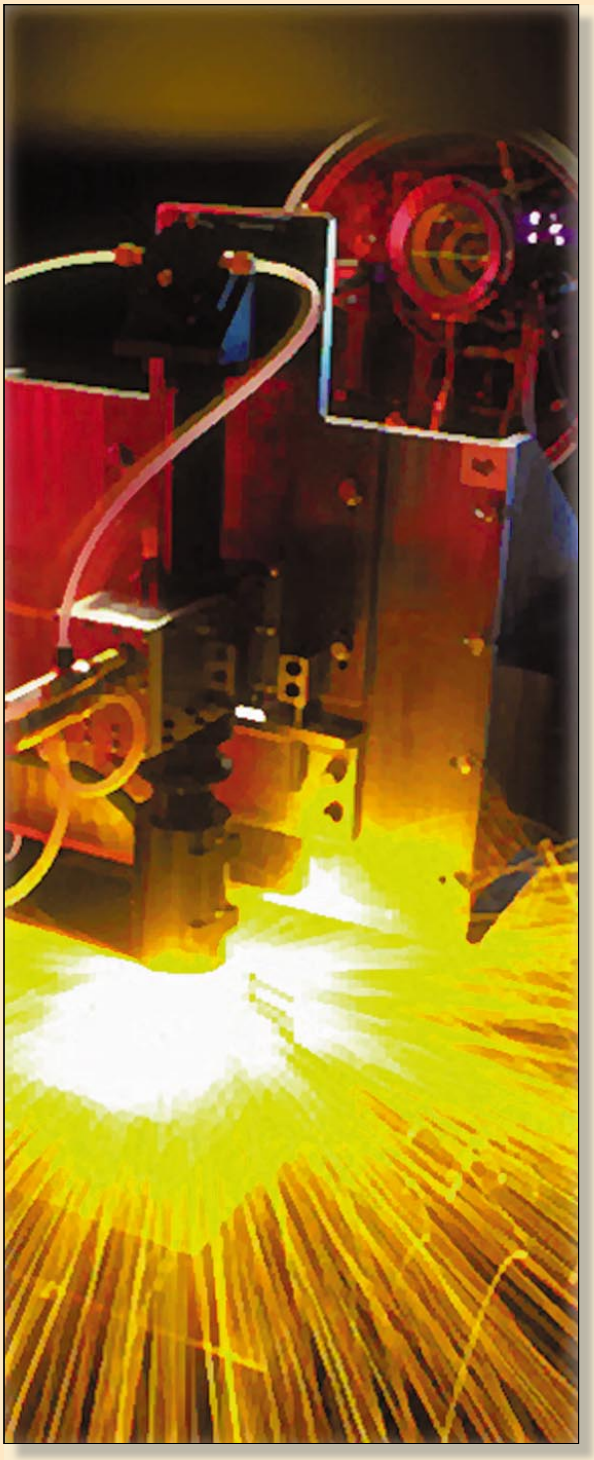
People

Engineering at LLNL 1997

Core Competencies

Core Technologies

Lawrence Livermore National Laboratory • University of California



Livermore's program to refurbish the W87 warhead was a key Engineering activity in FY97.

Contents

Engineering facilities are located throughout Lawrence Livermore National Laboratory.

Building 131 is the main Engineering facility.

Associate Director's Message

Fiscal year 1997 has been another year of significant activity in Engineering marked by increased emphasis on meeting key Laboratory milestones, continued attention to further operational improvements, organizational readjustments, staffing, and progress in cost management.

In the programmatic area, strong growth in the National Ignition Facility (NIF) and Accelerated Strategic Computing Initiative (ASCI) programs allowed us an unparalleled opportunity to participate in the most challenging engineering R&D programs currently undertaken in the country and the opportunity to apply our computational engineering efforts to important Laboratory deliverables in the weapons area. In spite of our relatively short-staffed situation for much of the year, we managed to meet all critical milestones, including the more aggressive "capability stretching" goals requiring extraordinary innovation and dedication.

In the operations area, Mechanical Engineering undertook substantial re-assignments of senior management responsibilities, and Electronics Engineering consolidated from four to three divisions. Both of these adjustments were made in an effort to better align the Directorate with its evolving customer base, particularly in the Laser and Nonproliferation, Arms Control, and International Security areas.

In parallel, the Voluntary Separation Incentive Program (VSIP) was completed, and through that process, Engineering reduced its workforce in selected areas by approximately 7% of its total employee base. This reduction, coupled with significant funding growth, allowed Engineering to measurably and positively impact its skill mix while improving its operational leverage, or flexibility. Overall, a year following the completion of VSIP, Engineering's productivity was up by 5%, while its flexibility had doubled; all this at a time where nationwide competition for engineering talent was at historic highs. In order to accomplish some of our staffing objectives, we had to establish innovative ways to augment our personnel, such as borrowing employees from downsizing U.S. Department of Energy (DOE) contractors, and thus contributing to the weapons complex's knowledge retention objectives.

Finally, Engineering costs were reduced for the fourth consecutive year, while the amount of funding directed toward competency development increased for the first time since recent cost reduction efforts began.

This report contains a detailed summary of our accomplishments. I hope you will find it both interesting and informative.

Associate Director

Overview of LLNL

Established in 1952, Lawrence Livermore National Laboratory (LLNL) is one of the world's premier applied-science national security laboratories. The primary mission of the Laboratory is to assure through the design, development, and stewardship of nuclear weapons, that the nation's stockpile remains safe, secure, and reliable and to prevent the spread and use of nuclear weapons worldwide. National security is a principal integrating theme at LLNL—with stockpile stewardship, nonproliferation and arms control, and Department of Defense projects its major elements.

The Stockpile Stewardship Program, the primary Laboratory program, is a science-based versus testing-based approach to maintaining stockpile safety and reliability. The idea is to replace weapons development and nuclear testing with weapons life extension and intensive computational and experimental research to provide the fundamental understanding necessary to ensure nuclear weapons safety, performance, and maintenance.

Stockpile stewardship is enhanced and complimented by a second pillar of national security at the Laboratory: countering the spread of weapons of mass destruction. In the broad areas comprising nonproliferation, arms control, and international assessments, the growth of new technologies has been exponential at LLNL. Our ability to produce advanced microsensors—from scientific concept to working field model—is just one of the many contributions LLNL has made to the nation in counterproliferation against nuclear, biological, and chemical weapons.

In addition, LLNL's unique competencies developed in support of its national security mission have become an important resource for U.S. industry and government. Programs include advanced defense technologies, energy, environment, biosciences, and the basic sciences.

Central to the Laboratory's success is its diverse, highly talented, and skilled workforce and its $4 billion capital invested in plant and research facilities. The University of California (UC) has managed the Laboratory since its inception, under contract with the DOE and its predecessors.

Funding and Workforce

In FY97 the Laboratory's budget was flat at approximately the previous $1 billion FY96 level. From this, $879 million was devoted to operations, and $140 million to capital investment projects. (See Figures 1 and 2.)

On average, LLNL's staffing level in FY97 consisted of 6,500 career employees (excluding summer hires and temporary employees) and 670 contract employees. (See the LLNL Staffing and Education Levels chart in the Appendix.) Scientists and engineers comprised 38% of the staffing mix, technical and crafts personnel 38%, and administrative and clerical 24%. Among the scientific staff, 37% were engineers, 30% were physicists. The remaining 33% of the scientific staff was comprised of chemists, computer scientists, environmental scientists, metallurgists, and other categories. (See the Engineering Staffing Profile in the Appendix .)

Figure 1. LLNL funding profile FY96-FY97.

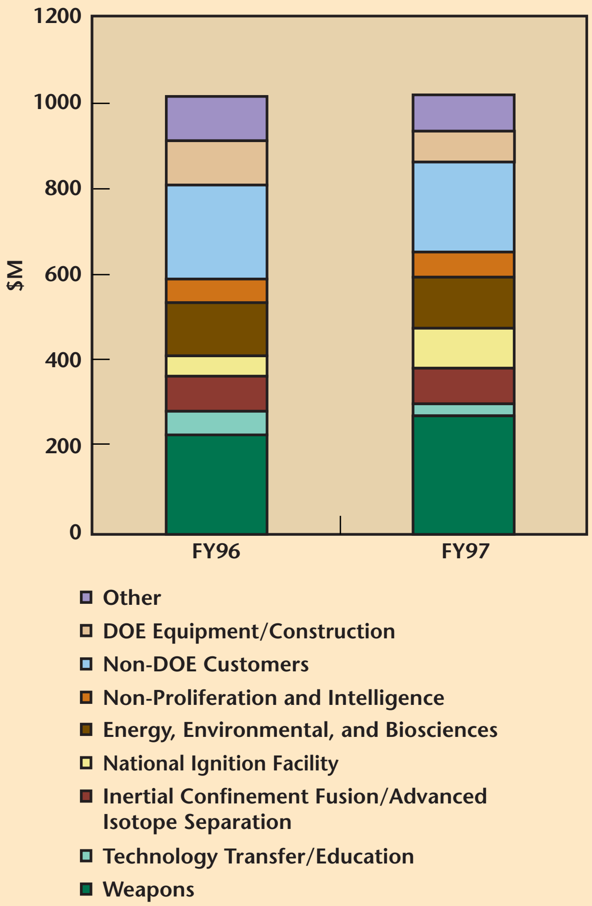
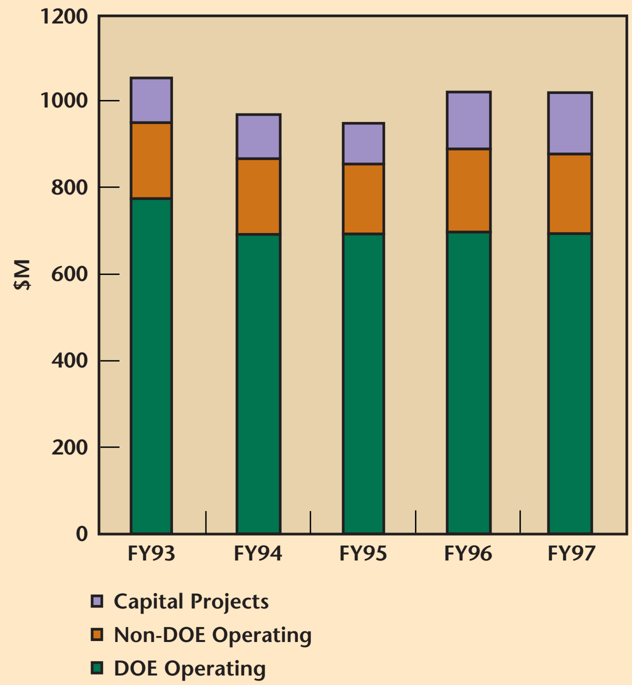


Figure 2. LLNL five-year funding trend.



Engineering Overview

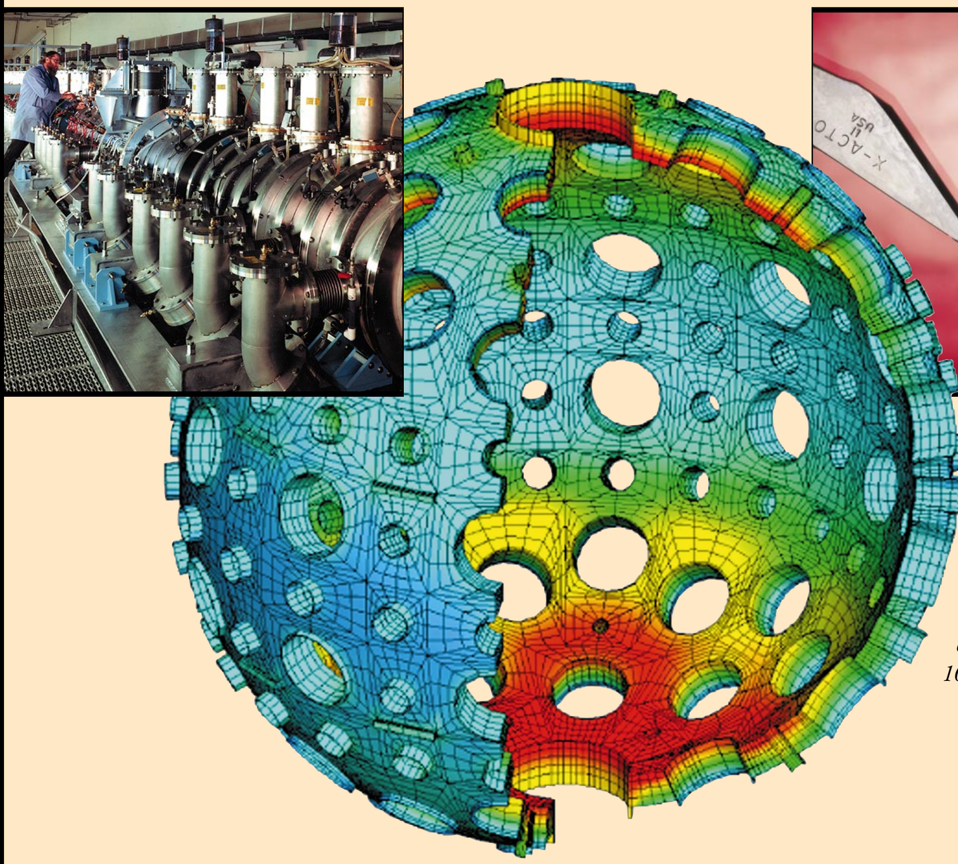
Mission

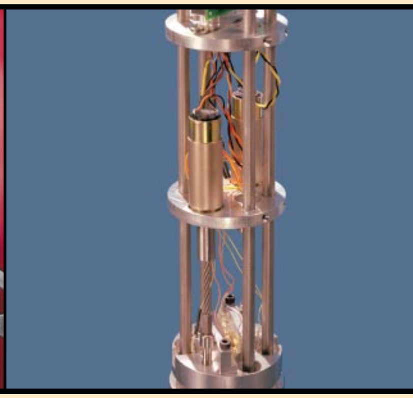
Engineering's mission is to turn physics ideas into reality. This means that Engineering designs and builds most of the Laboratory's experimental projects, which are used to conduct physics and engineering research. Engineering also does the engineering design of many of the Laboratory's end deliverables, such as weapons where it has cradle-to-grave responsibility. In addition, Engineering's mission is to conduct research in advanced engineering technologies so that new directions can be pursued by the Laboratory over time.

To fulfill its mission, Engineering provides the functional home for most of the engineering and technical talent working in the Laboratory, and as a consequence, Engineering hires virtually every engineer that works at LLNL. In addition, Engineering develops and maintains a significant number of facilities used for fabrication or to conduct engineering research. Finally, because Engineering is the largest scientific and technical organization at the Laboratory, and because of the Laboratory's matrix system that induces people to be dynamic by moving between projects from time to time, Engineering performs an internal technology transfer function that contributes significantly to the Laboratory's creativity.

In support of the variety of research and development activities at LLNL, Engineering conducts innovative research and development in the following four core competencies: integrated engineering of large-scale, complex applied physics systems; large, complex computational modeling and simulation; microscale engineering; and measurement science at extreme dimensionalities. These competencies form the foundation for the vitality of Engineering's core technologies: integrated mechanical, electrical, and controls system design; computational engineering; precision engineering; microsystems technology; signal and digital image processing; and non-destructive characterization.

Core Competencies





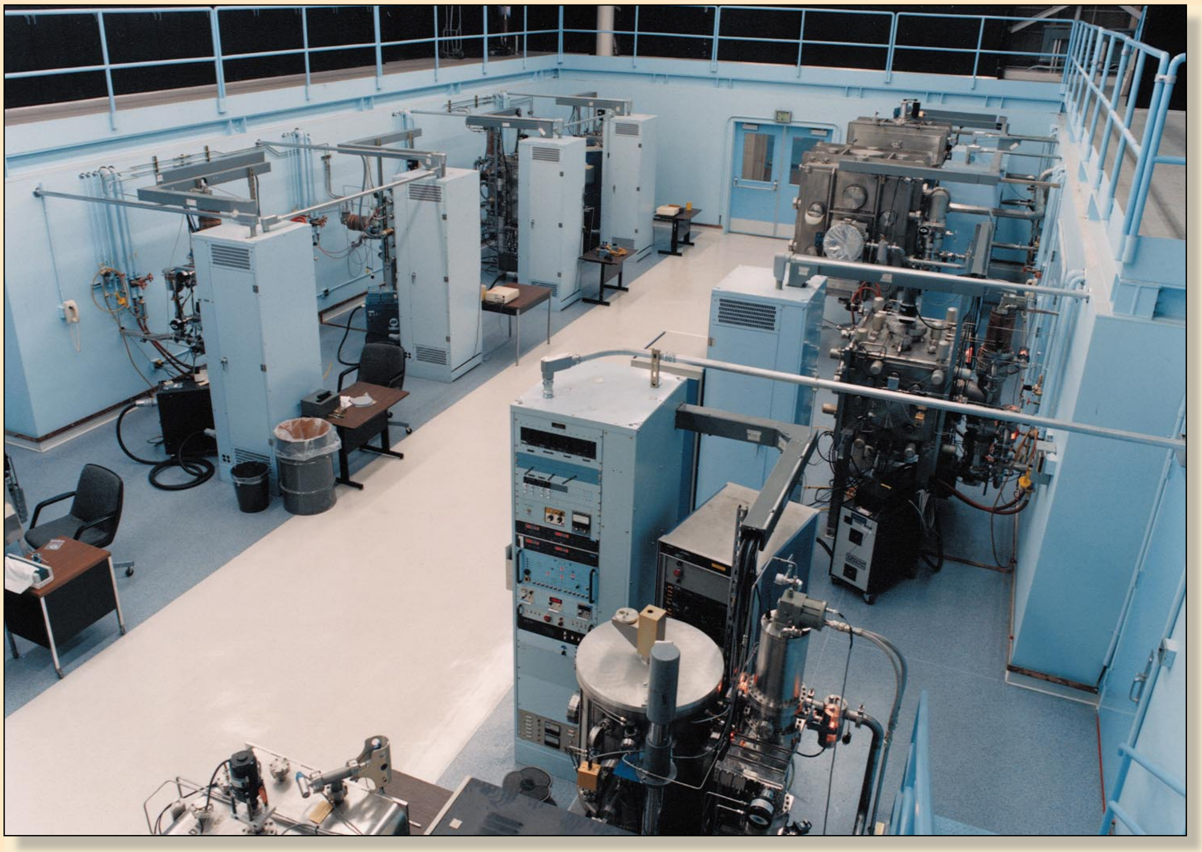
Shown from left to right are projects representative of Engineering research in the four core competency areas including the FXR upgrade project, the NIF target chamber modeled by LLNL's NIKE3D and TOPAZ3D codes, the world's first fullerene waveguide array developed by Engineering's Microtechnology Center (photographed between two X-acto knife blades to indicate scale), and the oil field tiltmeter which can image hydrofractures at least 10,000 feet below the surface of a well.

Organization

The Engineering Directorate is a multidisciplinary organization with expertise in most of the major engineering fields. In FY97, the Directorate was organized along two fundamental disciplines, mechanical and electronics engineering. (For further information refer to the Organization Chart in the Appendix.) Its wide-ranging capabilities are a direct outgrowth of Livermore's nuclear weapons work and the interdependence of weapons design, computational modeling, engineering, safety, and performance. The Directorate simulates engineering systems, improves systems designs, and tests performance when built. Engineering manages numerous large- and small-scale projects requiring complex interactions among many scientific disciplines. There are approximately 2,100 employees in Engineering, with approximately 1,800 typically assigned (matrixed) to work directly in support of other Laboratory organizations.

Engineering Facilities

Engineering owns and operates 30 facilities at the main LLNL site in Livermore. These facilities total 770,000 gross square feet, with 70% dedicated to working engineering laboratories, shops, and computer, equipment, and storage space, and 26% dedicated to office space. In addition, Engineering operates 36 buildings and magazines at Site 300, a 45-square-mile test site that LLNL manages near Tracy, California. (See the Site Map in the Appendix.)



The Vacuum Process Facility pictured above allows parts as large as 100 cm in diameter to be coated or etched uniformly. The modular design of these systems permits complex coating designs to be fabricated using the optimal process for the application at hand.

Funding and Workforce

Funding

Engineering's $331.4 million FY97 funding came from three sources: programmatic support, distributed costs, and direct funding.

- Programmatic support is derived from LLNL programs. Engineering assigns approximately 80% of its personnel to work in the programs. In FY97, programmatic support accounted for approximately $270 million, or 82% of Engineering's funding. The associated funding is managed within the programs, but pays for the salaries of Engineering's matrixed personnel.

- Distributed costs are associated with the following: Organizational Personnel Charges (OPC) to fund activities such as technology development, personnel management, administration, recruitment, conferences and training; Organization Facilities Charges (OFC); recharges from Engineering Service Centers such as Manufacturing and Materials Engineering, Electronics Manufacturing, and the Engineering Records Center; General and Administrative (G&A) costs; and Program Management Costs (PMC). Distributed costs accounted for $54 million, or 16% of Engineering's FY97 funding.

- Engineering's third funding source, direct funding, is for work done under contract for the DOE or other government or commercial customers. It also includes the Laboratory Directed Research and Development (LDRD) program. Direct funding accounted for $7 million, or 2% of Engineering's FY97 funding.

Workforce

As LLNL's largest scientific organization, Engineering provides support to all Laboratory programs. In FY97, Engineering's full-time equivalent (FTE) workforce increased by 1.3%. As a result of stockpile stewardship efforts, support to Defense and Nuclear Technologies showed the greatest increase from October of 1996 to September of 1997.

Figure 3. Engineering funding by budget type FY96-FY97 (excluding programmatic support).

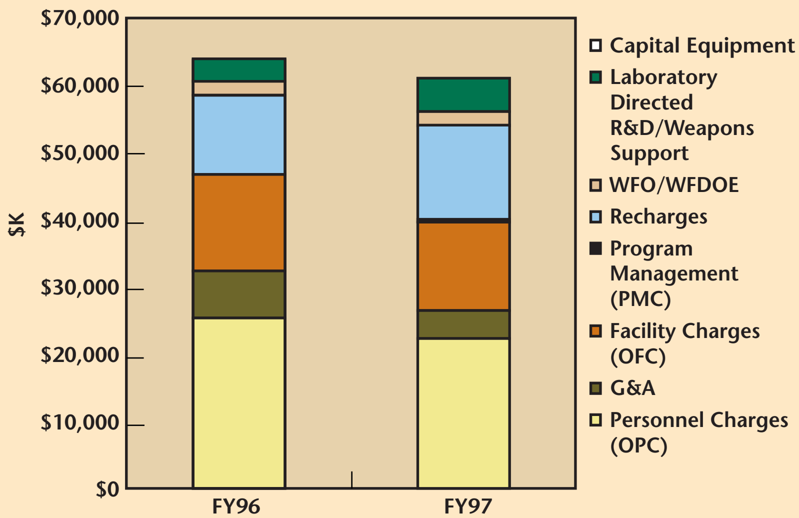
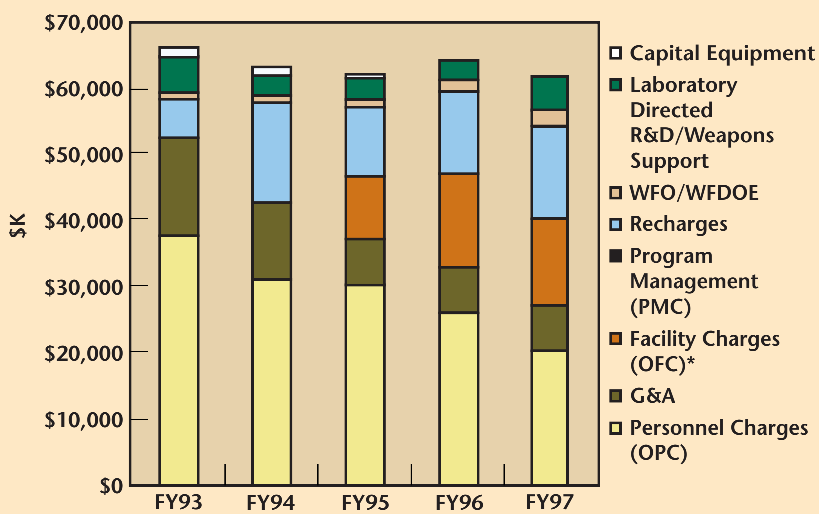


Figure 4. Engineering five-year funding trend (excluding programmatic support).



* FY96 & FY97 reflect institutional costs (LFC) passed on to Engineering

FY97 Significant Accomplishments

Business Accomplishments

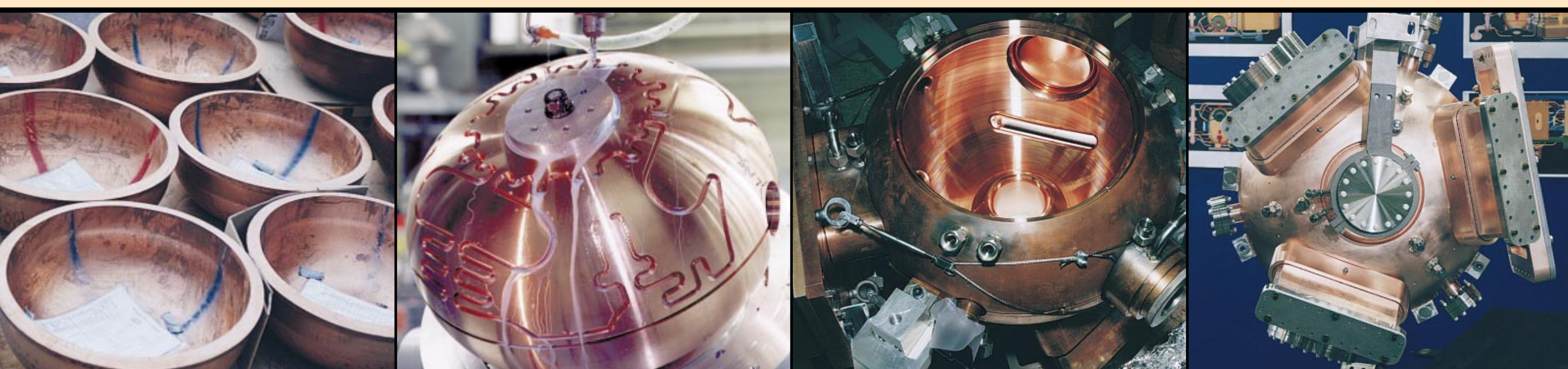
In FY97, we pursued the next level of our strategic plan. We defined a number of high-level, long-term goals for the Directorate, which if achieved would be both significant and measurable. The three key goals are to:

- Deliver on all program milestones, including the Laboratory's stretch commitments.
- Enable future hundred-million dollar programs by developing technology that gives the Laboratory a competitive advantage.
- Build Engineering's national reputation.

The following is a list of our key FY97 accomplishments. First and foremost, Engineering met all critical Laboratory program milestones, including those involving the design and/or fabrication of large facilities such as the $1.2 billion National Ignition Facility (NIF), the United States Enrichment Corporation's (USEC) AVLIS (Atomic Vapor Laser Isotope Separation) pilot enrichment plant, and Stanford's PEP-II (Positron-Electron Project) facility.

Meeting these milestones required that we make significant organizational changes and reassign responsibilities among Engineering's senior management team. In addition, Engineering decided to aggressively participate in the Laboratory's Voluntary Separation Incentive Program (VSIP) by allowing 150 employees to participate. This served to improve the organization's skill mix and also improve its long-term operating leverage or flexibility (which it raised by some 15%).

To supplement its workforce needs, Engineering hired some 190 people in FY97 (and lost 90 through normal attrition) and moved about 40 people from Allied Signal in Kansas City (a DOE contractor) to Livermore. This helped mitigate a potential layoff at Allied Signal and contributed to the DOE complex's knowledge retention objectives. Additionally, it addressed urgent LLNL programmatic needs with highly skilled, security cleared personnel.



Shown from left to right are four of the many steps in the radio-frequency cavity manufacturing process. These cavities are key components for the B-factory at the Stanford Linear Accelerator Center.

Second, Engineering devoted more efforts to further improving its cost structure and increasing the resources made available for core competency development. In FY97, Engineering's OPC was reduced to the lowest level (16.8%) since the accounting restructuring was instituted in FY95 (when the rate was 23.3%). This, combined with the Institution's six-point G&A rate reduction, allowed the true cost of business to be reduced by 5% from FY96, and 11% from FY95.

In addition to overhead cost reductions, Engineering positioned itself to double the funding available for core competency development without increasing the cost to its customers. Entering FY98, this objective was largely achieved through a combination of organizational restructurings, divestment from facilities and investments no longer strongly coupled with the Laboratory's future, and by taking full advantage of the Laboratory's tailored VSIP activities.

In FY97, Engineering continued to make progress on the consolidation plan with the main thrust being the consolidation of Electronics Engineering and Mechanical Engineering fabrication capabilities in the Manufacturing & Materials Engineering Complex (Building 321). This year the welding shop was reconfigured into a smaller space, the machine tool development labs were moved to building 432, and the waterjet cutting machine and the Certification of Process gage were moved to new locations in Building 321. Over 8,000 square feet of shop space was cleared out and refurbished. In addition, design began for converting 14,000 square feet into new offices and laboratories, and an 11,000 gross square feet office trailer complex (T3276), formerly occupied by the MMED staff was returned to the institution and subsequently demolished.

In line with its long-term facility consolidation and improvement plan, a $20M line-item for the Engineering Core Technology Center/321 Complex Upgrade was submitted to DOE/HQ, and approval obtained to prepare a conceptual design report for submittal to DOE in March 1998.

Engineering also successfully acquired $900K in General Plant Projects funding to expand the Building 153 Microtechnology Center so that it can accommodate an increased volume of business across the Laboratory. This includes part of the newly formed $250 million Extreme Ultraviolet Lithography Limited Liability Corporation venture which LLNL, Sandia National Laboratories, Lawrence Berkeley National Laboratory, TRW, Intel, Advanced Microdevices, and Motorola have jointly entered into.

Finally, Engineering translated its long-term goals set to one that is more broadly applicable to the type of work its employees do, and embarked on a process to incorporate these goals more directly into each employee's performance appraisal beginning in FY98.

Technical Accomplishments

Atomic Vapor Laser Isotope Separation (AVLIS) Separator and Laser Tests

Beginning in July of 1995, the largest technology transfer in the history of the Laboratory began. Sponsorship of the entire AVLIS program was transferred to the U.S. Enrichment Corporation (USEC). The technology of laser isotope separation of uranium has been under development at the Laboratory for over 25 years. In the mid 1980's it was selected as the preferred technology for the enrichment of uranium for reactor fuel over competing gaseous centrifuge technology.

It is the intent of USEC to commercialize the process to supply its share of the world market for enriched uranium. Engineering is providing much of the engineering design and testing support for this program. It is a cost and schedule-driven program that is poised to become part of a private corporation when the sale of USEC is completed either by an initial public offering or purchase by another company or corporation.

For the process to be economically viable, it must be transitioned to a production plant. The program and program support personnel faced a daunting challenge last year. USEC needed to run the facility for more hours than it had totally run in the last ten years. We are happy to report that not only was this accomplished, but almost all of the objectives were achieved on each run. We successfully completed five runs in 1997 totaling more than 1,600 hours. Three of the runs exceeded the initial operating goal of a continuous 400-hour run. The final two runs (S-12 and S-13) combined the laser system with the separator system to demonstrate plant-like enrichment.

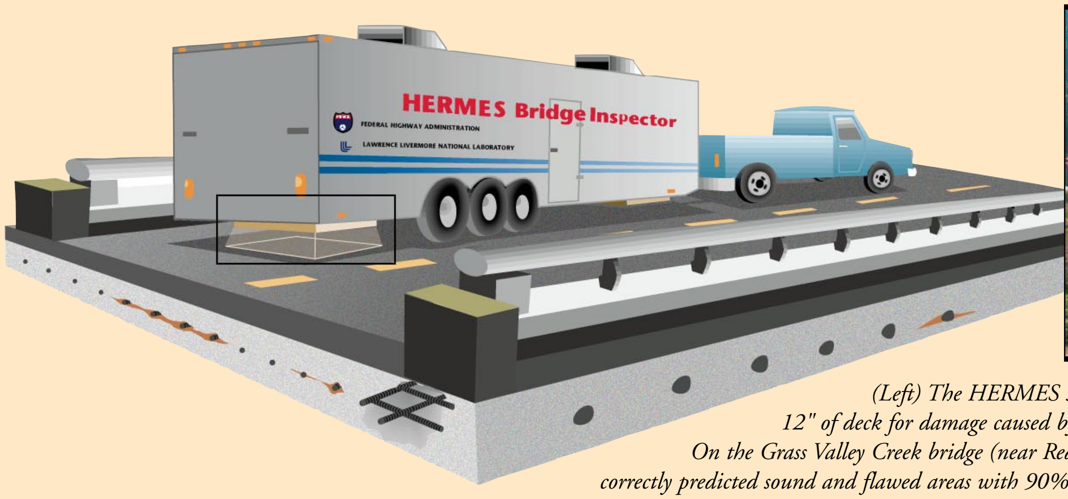
The AVLIS process enriches uranium alloy feedstock to a level needed to fuel nuclear power plants. Physically, the raw material is injected in the form of a bar (left) and emerges as nuggets (center) containing a higher level of U-235, the isotope that provides the fission energy. In an actual production scenario, the enriched nuggets produced by AVLIS would then be processed into fuel rods by commercial fuel fabricators. AVLIS incorporates heavy engineering with the latest in opto-electronics and distributed real-time control systems (right).

HERMES—A Nondestructive Bridge Inspection System

Bridge inspection with the prototype High-Performance Electromagnetic Roadway Mapping and Evaluation System (HERMES) is a radical departure from current methods. In traditional methods of bridge inspection, the road is closed, the asphalt overlay removed, and the surface inspected manually for signs of underlying defects in the bridge deck. With HERMES, inspection takes place at highway speeds while the roadway remains open to traffic. Data gathered by this mobile array of 64 micropower impulse radar (MIR) sensors are processed with sophisticated imaging algorithms creating three-dimensional maps of the concrete. These subsurface maps show defects and other features, such as rebar corrosion, water damage, and delaminations, to depths of approximately one foot with image resolution as low as 0.4 inch. The MIR technology that makes HERMES possible was also developed in the Engineering Directorate.

The prototype of HERMES, developed by Engineering for the Federal Highway Administration (FHWA), was successfully road tested this summer on the Grass Valley Creek bridge in Northern California. The low-cost, speed, and convenience of HERMES make it possible to inspect many more bridges—a topic of national concern because thousands of bridges are over 50 years old and subject to failure. And HERMES has a detection probability of 90%, several times that of the most competitive alternative method. These features make it feasible to evaluate the degradation of a bridge over time via periodic inspections and to base repair priorities on actual conditions. The FHWA expects that the savings realized by avoiding the closure of one major bridge could easily pay for the entire cost of HERMES R&D. Aside from the increased public safety, the savings from using HERMES are estimated at $100 million per year on bridge inspections alone.

LLNL is currently developing similar systems to detect buried land mines. And with some modifications to HERMES, such as side deployment of sensors, greater imaging depth, and robot vehicles, it would also be possible to extend these techniques to inspect underground highway and railway tunnels, railway roadbeds, elevated highways and off-ramps, airport runways, and other critical structures where failure would be catastrophic (e.g., stadiums, dams).



(Left) The HERMES system inspects the top 12" of deck for damage caused by corrosion. (Right) On the Grass Valley Creek bridge (near Redding, CA) HERMES correctly predicted sound and flawed areas with 90% accuracy.

Zephyr

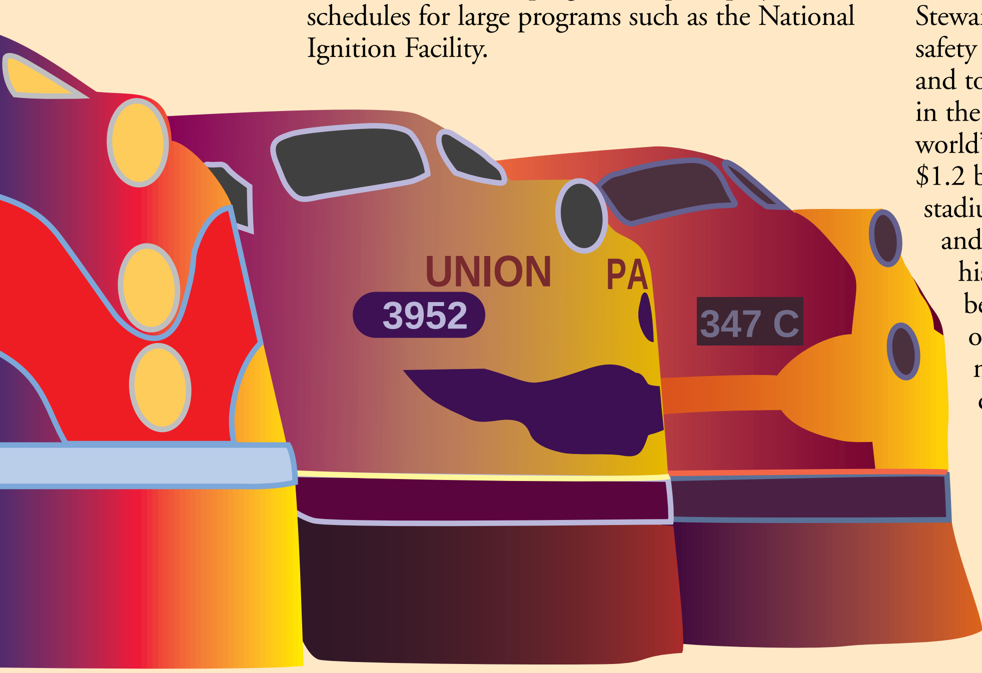
Zephyr, a streamlined, paperless, procurement system, was named for the famous California streamliner. The Electronics Engineering Department, Administrative Information Systems, and Procurement developed a pilot implementation of this highly integrated engineering development cycle that cuts procurement times by as much as 90% as it reduces the cost of paper processing. The concept merges engineering and commerce via secure (i.e., encrypted and password-protected) transactions over the Internet. Small and medium-sized (SMEs) businesses are encouraged to prequalify for Zephyr transactions with LLNL. Typically, soon after engineering design release, a buyer issues an electronic request for quote package on an encrypted Zephyr home page (http://zephyr.llnl.gov/). Then, again electronically, Zephyr takes care of the announcement, solicitations for bid-quote, award, technical data exchange, payment, delivery tracking, and the record-keeping and audit trail requirements. The system also assists engineers to rapidly prototype designs and efficiently find collaborators via the Internet, further helping to compress project schedules for large programs such as the National Ignition Facility.

Zephyr—the concept is called Engineering and Commerce on the Internet (ECI)—received a Best Practices Award from the DOE and the DoD, and was one of the DOE initiatives for the Advanced Manufacturing National Information Infrastructure to help advance American manufacturing. Zephyr will link Engineering not only to the Procurement and Finance organizations at LLNL, and be adopted for Lab-wide procurements, but will also be employed on both a national and international scale. It was linked to the Commerce at Light Speed (CALS) Working Group, U.S. Department of Commerce, of which LLNL is a member, and ultimately will help bring about the Internet-based electronic marketplace. Presently, the University of California's Haas School of Business, Fisher Center for Business and Management, is finishing a Zephyr Case Study detailing the development of LLNL's unique engineering capability.

NIF Title I Review Completed

The National Ignition Facility (NIF) is being built as a major element of the DOE's Stockpile Stewardship Program to preserve confidence in the safety and reliability of the U.S. nuclear weapons and to preserve core nuclear weapons competencies in the absence of nuclear testing. It will be the world's largest laser and has an estimated cost of $1.2 billion. It will be the size of a modern sports stadium and is the largest construction project and permanent facility in the Laboratory's history. It will combine 192 separate laser beams that are designed to be fired simultaneously and focus on a target capsule 1-to-3 millimeters in diameter containing deuterium-tritium fuel. The beams will precisely compress and heat this target to 100 million degrees.

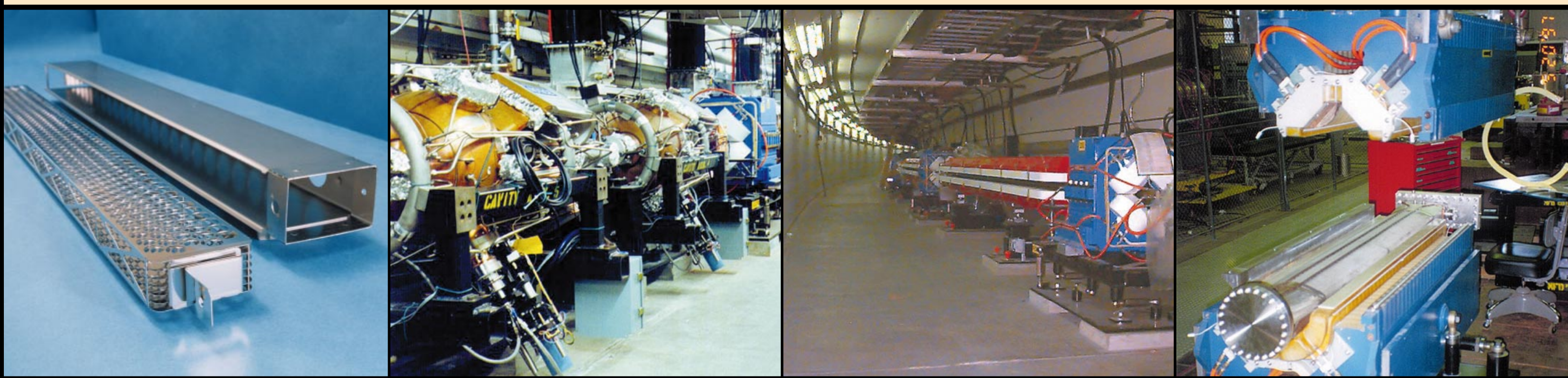
This year we completed 100% of the conceptual design phase (Title I) of the project.



PEP II High-Energy Ring

The PEP II (Positron-Electron Project) High Energy Ring is one of the two charged-particle storage rings at the B-Factory, an enormous accelerator facility scheduled for completion in 1999 by a consortium between Stanford, LLNL, and Lawrence Berkeley National Laboratory. This B-Factory, located at the Stanford Linear Accelerator Center (SLAC), and another in Japan, will generate millions of B mesons and anti-B mesons through the collision of electrons and positrons moving at near the speed of light. A key feature of this collider is that electrons and positrons will circulate and collide with unequal (or asymmetric) energies so scientists can better study the particles generated in the collisions. Scientists from over 75 institutions world-wide, including LLNL, will use these particles to study charge-parity violation—the small differences in the way that certain short-lived particles and their antiparticles decay. Charge-parity violation is thought to be the reason that the universe seems to be composed almost exclusively of matter. Finding out why the universe contains essentially no antimatter is a necessary step in understanding the fundamental nature of matter and energy.

In addition to previous and ongoing LLNL engineering and manufacturing work on other components of the B-Factory, in 1997 the Accelerator Technologies Engineering Group (ATEG) contributed to the design and fabrication of several key PEP II accelerator components, including vacuum systems, magnets, radio-frequency oscillator cavities, and beam dumps. The PEP II High Energy Ring, an underground ring 2.2 km in diameter at SLAC, was operated for the first time with 9-GeV electrons on June 3, 1997. By June 26, the stored lifetime of the beam was increased to more than 3 hours and reached a 50-milliamp (mA) beam current. This three-year project cost \$170 million and was successfully completed on time, meeting a major DOE milestone.



LLNL Engineering made a number of significant contributions to the PEP-II High Energy Ring (HER). From left to right, ATEG developed, designed, built and tested the distributed ion pumps for the HER arc sections; MMED fabricated and assembled the 26 rf cavities for the project; ATEG designed the vacuum chambers for the HER straight sections; and ATEG designed the septum quadrupole magnets and vacuum chambers for the HER interaction region.

High-Resolution Computed Tomography of a Weapons Pit

Engineering teamed with imaging scientists from the Laser Directorate to produce the first 3-D x-ray images of a nuclear weapons pit. This was done for the Enhanced Surveillance Program. This imaging system employs 9-MV Bremsstrahlung radiation. The pit computer tomography data set has produced a full 3-D pit image that reveals internal features that cannot be seen by any other nondestructive method. It employs a volume radiograph imaging system that produces a point spread function with a full width half maximum of 100 μm. This results in a resolved volume 3-to-10 times smaller than previously achieved. This is a very significant development for the Stockpile Stewardship Program.

Tiltmeter

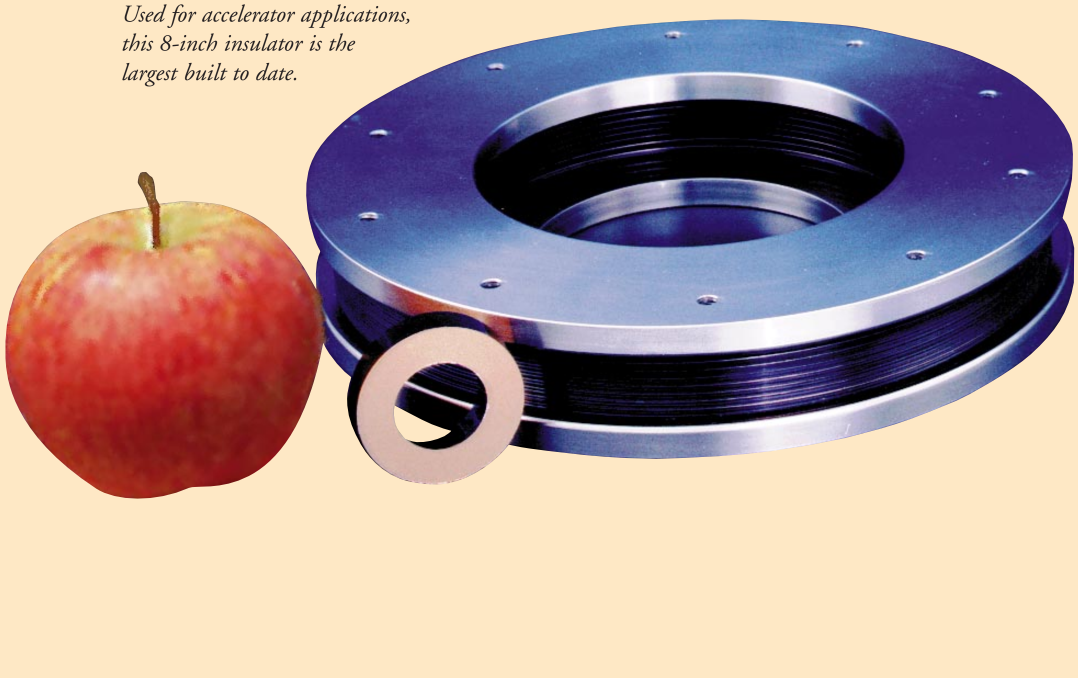
This new device, honored with an R&D 100 Award, is used in oil field production. Tiltmeters are sensitive instruments able to measure atomic-scale changes in the tilt of the earth's surface. Although tiltmeters have been used in oil fields for years, they have lacked the sensitivity to measure the tiny surface tilts from deep wells, which are very expensive to drill.

Oil companies pump water under high pressure into their wells to create cracks in the oil-containing rock layers which increases production. The water pressure causes a tiny bulge in the earth's surface. Although this bulge is about a mile in diameter for a well two miles deep, it is only about one-millionth of an inch high. The new tiltmeter measures the infinitesimal tilt caused by this bulge.

Ultra-High Gradient Insulator

The new ultra-high gradient insulator (UHGI) has also been honored with an R&D 100 Award. Researchers from LLNL and Allied Signal, Kansas City have pioneered the new insulator. The motivation for this work was to improve key elements in nuclear weapons systems. The device sustains about four times the electrical voltage of similarly sized conventional insulators. Use of the new insulator can shrink these devices to one-fourth their current size. The fundamental advance of the UHGI device is that it uses extremely thin layers of alternating conducting and insulating material to sustain electrical voltage. It also offers a reliability advantage over current insulators. Once a conventional insulator breaks down, it will not run again at the same operating voltage. In contrast, the UHGI insulator can be ramped-up or reconditioned to its original operating voltage.

Used for accelerator applications, this 8-inch insulator is the largest built to date.



Multiscale ElectroDynamics

This system was also selected for an R&D 100 Award last year. It is a computer code that runs on workstations and allows the user to construct a "virtual" optical bench. It can handle scale lengths that vary by 10^6 and reduces the development cycle time and engineering costs by as much as 80%. It is being used for the development of micro-optic devices used in new high-speed computers and communications systems.

It allows designers to quickly and accurately explore new photonics design and packaging approaches by eliminating the tedious trial and error fabrication, test, and development cycle. It has already been used by an industrial collaborator to speed up the design and implementation of an optical communication systems.

Dugway Joint Field Trials

In the aftermath of Desert Storm and Hussein's threat of the use of biological warfare (BW) agents, a team was assembled with the mission to develop defenses against these weapons. Along with members of the Nonproliferation, Arms Control, and International Security Directorate and the Biology and Biotechnology Research Program, Engineering was invited to participate in the Joint Field Trials III at Dugway Proving Groups in Utah. The JFT III field trials were the first trials at which realistic sample concentrations were used.

We were able to build upon two world-leading proprietary technologies, the flow-stream-wave-guide flow cytometer, and the silicon-sleeve-based polymerase chain reaction (PCR) instruments to make small, portable instruments, "miniFlo" and "mini-PCR," respectively. The former was used for antibody-based assays, and the latter was used for nucleic-acid-based assays. Using the miniFlo we achieved 100% detection of all concentrations of B.g., the anthrax simulant, with 0% false positives for blanks and only 1% false positives due to cross reactivity of the antibody reagents. No other technique has ever shown a perfect score for true positives and no false positives for blanks.

(Left) Photo of miniFlo, the ID-capable cytometer that performed detection and quantification of unknowns at Dugway JFT III. (Center) The world's first fully automated PCR system used at the DoD "portal shield" field trial. (Right) Emergency response person using mock-up of PCR biodetector.

Honors and Awards

R&D 100 Awards

Each year *R&D Magazine* selects the 100 most technologically significant products and processes submitted for consideration and honors them with an R&D 100 Award. Winners are chosen by the editors of the magazine and a panel of 75 experts in a variety of disciplines. Corporations, government laboratories, private research institutes, and universities throughout the world vie for this “Oscar” of applied research. The R&D 100 judges look for products or processes that promise to change people’s lives by significantly improving the environment, health care, or security. In FY97, the following Engineering employees won awards:

Frank Snell—*Absolute Interferometer*

Steve Herman—*Femtosecond Laser Materials Processing*

Steve Sampayan, Dave Trimble, Bob Stoddard and Dave Sanders—*Ultra-High Gradient Insulator*

Richard Ratowsky, Jeffrey Kallman, Robert Deri, and Michael Pocha—*Multiscale ElectroDynamics (MELD)*

Steven Hunter—*Oil Field Tiltmeter*

LLNL Director’s Performance Awards

Sally Bahowick—*Portable Treatment Units*

George Metzger—*Portable Treatment Units*

Maurice Hernandez—*Portable Treatment Units*

Fred Holdener—*B-Factory Project at SLAC*

Leonard Silva—*AVLIS Dye Laser Facility Expansion*

Samuel Rodriguez—*NIF Title I and II Design Packages*

Anthony Gonzales—*NIF Title I and II Design Packages*

Michael McDaniel—*NIF Title I and II Design Packages*

Wayne Whistler—*NIF Title I and II Design Packages*

Kenderick Wong—*NIF Title I and II Design Packages*

Rudy Cavitt—*NIF Title I and II Design Packages*

Steve Benson—*Laser Cutting Project*

Robert Cross—*Laser Cutting Project*

Donald Frank—*Laser Cutting Project*

Bradley Golick—*Laser Cutting Project*

Jeff Klingmann—*Laser Cutting Project*

Mark LaChapell—*Laser Cutting Project*

Richard Lanza—*Laser Cutting Project*

Keith Peterman—*Laser Cutting Project*

Douglas Sweeney—*Laser Cutting Project*

Steven Telford—*Laser Cutting Project*

Graham Thomas—*Laser Cutting Project*

Frank Snell—*EUVL Milestone Technology Team*

Don Masquelier—*Mini-flow Cytometer*

Steve B. Brown—*Joint Field Trials III at Dugway, Utah*

Dean Hadley—*Joint Field Trials III at Dugway, Utah*

Raymond Mariella—*Joint Field Trials III at Dugway, Utah*

James Richards—*Joint Field Trials III at Dugway, Utah*

Paul Stratton—*Joint Field Trials III at Dugway, Utah*

Don Masquelier—*Joint Field Trials III at Dugway, Utah*

Other Awards

Zephyr Project—*DOE Best Practice*

David Gutierrez—*NPR Hammer Award*

Glenn Meyer—*Award for Excellence in Technology Transfer*

Dino Ciarlo—*Award for Excellence in Technology Transfer*

Dennis Chakedis—*DOE Appreciation Award (EEO & Diversity Conference)*

Roberto Ruiz—*Spiral Track Autonomous Robot (STAR). Finalist in* Discover *Magazine Awards for Technological Innovation*

Del Eckles—*Spiral Track Autonomous Robot (STAR). Finalist in* Discover *Magazine Awards for Technological Innovation*

Erna Grasz—*Spiral Track Autonomous Robot (STAR). Finalist in* Discover *Magazine Awards for Technological Innovation*

Mark Perez—*Spiral Track Autonomous Robot (STAR). Finalist in* Discover *Magazine Awards for Technological Innovation*

Greg Tietbohl, Petawatt Project—*Best of What's New Award 1996*—Popular Science *Magazine*

Maynard Holliday—*the Former Soviet Union Meritorious Service Award*

Don Lesuer—*Elected Fellow of the American Society of Materials*

Shin-Yee Lu—*3-D Imaging*-Discover *Magazine Finalists*

Bob Addis—*Alumnus of the Year at Cal Poly, San Luis Obispo*

Karla Hagan—*Senior Member of The Institute of Electrical and Electronics Engineers, Inc.*

Debra Krulewich—*U.S. Department of Energy Integrated Manufacturing Predoctoral Fellowship for 1997-1999*

Key Challenges for the Future

In the coming year, our key challenges are:

- To continue to deliver on all program milestones, including the Laboratory's stretch commitments.

- To begin building a national reputation for Engineering and to appropriately relate this across the variety of work we do. Building our reputation is necessary to allow LLNL to take full advantage of our workforce's intellectual capacity and to make it possible for the Engineering Directorate to continue to attract and retain truly exceptional people.

- To implement our new technology plan (transitioning our nine Thrust Areas to five Centers), and, in each of our core technologies, to lay the foundation for replicating the success characteristics of DYNA—a breakthrough, unique innovation that put Engineering on the national map, and that broadly and significantly impacted Laboratory programs.

- To further improve our flexibility so that we can position ourselves to seamlessly respond to the eventual ramp-down of major Laboratory projects, and to attain and sustain a wisely invested, healthy level of capital and core competency investment.

- To strengthen our leadership team and help the Laboratory capture the next multi-hundred million dollar program.

- To improve our safety record.

Appendices

Charts and Graphs

LLNL Appendices

LLNL Costs by Major Program ($M) FY96-FY97

	FY96	**FY97**
Weapons	230.8	269.7
Technology Transfer/Educ.	51.2	20.8
Inertial Confinement Fusion/Adv. Isotope Separation	84.3	84.8
National Ignition Facility	48.1	96.8
Energy, Environmental, and Biosciences	126.9	119.5
Nonproliferation & Intelligence	56.0	60.3
Non-DOE Customers	217.1	212.3
DOE Equipment/Const.	100.3	72.1
Other	101.9	82.6
	1016.6	**1018.9**

	FY96	**FY97**	**FY98 Plan 9/30/97**
DP01-CORE Stockpile Stewardship	203.4	241.2	260.8
DP04-Stockpile Mgmt.	27.4	28.5	38.3
Technology Transfer/Educ.	51.2	20.8	7.8
ICF	83.7	84.5	89.0
NIF	16.9	29.3	50.0
GA-Fissile Matl. Disposition	8.9	15.2	18.0
Nonproliferation & Intelligence	56.0	60.3	70.5
Env. Rest. & Waste Mgmt.	57.3	51.4	48.0
Other Defense	22.8	20.0	14.9
Adv. Isotope Separation	0.6	0.3	0.0
Magnetic Fusion	11.0	9.8	10.6
NERSC	14.4	0.0	0.0
Biomedical & Environmental	23.0	22.3	22.9
Basic Energy Science	9.5	8.6	8.8
Energy Research	17.2	12.1	16.4
SUBTOTAL DOE DIRECT OPERATING	**603.3**	**604.4**	**656.0**
WFDOE:			
NIF	0.3	0.0	0.0
Pantex	6.8	2.6	1.0
TPX-Princeton	-0.5	0.0	0.0
TRW-Waste Management	14.7	16.7	17.0
Other WFDOE	66.2	63.2	56.9
SUBTOTAL WFDOE	**87.5**	**82.6**	**74.9**
TOTAL DOE OPERATING	**690.8**	**687.0**	**730.9**

LLNL Costs by Major Program ($M) FY96-FY97 (continued)

	FY96	FY97	FY98 Plan 9/30/97
Non-DOE:			
CEA-France	11.9	6.6	3
U-AVLIS (USEC)	82.7	75.7	73
Other NON-DOE	99.7	110.0	134.6
SUBTOTAL Non-DOE	**194.3**	**192.3**	**210.6**
SUBTOTAL OPERATING	**885.1**	**879.3**	**941.5**
DOE Equipment	38.6	29.4	20.7
DOE GPP	5.6	6.0	4.9
DOE Line Item Construction	56.1	36.6	37.5
NIF Capital	31.2	67.5	140.7
	1016.6	**1018.9**	**1145.3**

LLNL 5-Year Funding Trend

	FY93	FY94	FY95	FY96	FY97
DOE Operating	775.3	693.2	689.4	690.8	687
Non-DOE Operating	176.5	164.8	163.7	194.3	192.3
Capital Projects	97.2	107.2	91.9	131.4	139.5
	1049.0	**965.2**	**945.0**	**1016.5**	**1018.8**

Note: DOE Operating includes WFDOE & DOE Direct Operating

LLNL Staffing & Education Levels-9/30/97

Scientists and Engineers	PhD	ENGR	MS	BS	AA	None	TOTAL
Physicist (270)	610		91	30		2	733
Chemist (242)	122		32	40			194
Engineer/Patent Eng. (168, 249)	267	4	403	227	2	19	922
Mathematician (285)	18		2	1			21
Computer Sci./Math Prog. (285)	50	1	176	197	2	8	434
Biomedical Sci. (225, 277)	18		11	15			44
Biophysicist (235)	2		4				6
Biochemist (221)	1						1
Environmental Scientist (230)	16		25	25			66
Metallurgist (265)	26	1	6	2	1		36
M.D. (Research/Staff) (263)	6						6
Political Scientist (295)	8		5	2			15
	1144	**6**	**755**	**539**	**5**	**29**	**2478**

Administrative and Clerical	PhD	ENGR	MS	BS	AA	None	TOTAL
Management (196, 197)	15		54	34	1	16	120
Professional (163-165, 169, 170)	5		21	26	1	16	69
Administrative (100-162)	10		101	202	75	349	737
Clerical/Gen'l Serv. (400-462)			2	39	58	549	648
	30		**178**	**301**	**135**	**930**	**1574**

Technical and Crafts	PhD	ENGR	MS	BS	AA	None	TOTAL
Security/Fire Dept (051, 055, 650-656)			1	23	39	138	201
Technical (302-339, 347-391, 502-588)	1		28	281	597	826	1733
Trades (722-799, 805-990)				14	73	414	501
Facilities/OJT/Gen. Helper (700, 701, 704, 801)					1	4	5
	1		**29**	**318**	**710**	**1382**	**2440**
	1175	**6**	**962**	**1158**	**850**	**2341**	**6492**

Appendices

Engineering Costs by Budget Type FY96-FY97

	FY96	FY97	
Personnel Charges (OPC)	$26,111	$21,159	40.8%
G&A	$6,664	$5,890	10.4%
Facility Charges (OFC)	$13,880	$12,921	21.7%
Program Management (PMC)	$131	$295	0.2%
Recharges	$11,973	$13,662	18.7%
WFO/WFDOE	$2,141	$2,404	3.3%
Laboratory Directed R&D/Weapons Support	$2,945	$4,781	4.6%
Capital Equipment	$90	$215	0.1%
	$63,935	**$61,327**	

Note: G&A does not include Technology Transfer

Engineering 5-Year Costs

	FY93	FY94	FY95	FY96	FY97
Personnel Charges (OPC)	$37,394	$30,939	$30,147	$26,111	$21,159
G&A	$14,580	$11,761	$6,840	$6,664	$5,890
Facility Charges (OFC)	$0	$0	$9,554	$13,880	$12,921
Program Management (PMC)	$0	$0	$80	$131	$295
Recharges	$6,102	$14,936	$10,114	$11,973	$13,662
WFO/WFDOE	$900	$897	$1,059	$2,141	$2,404
Lab Directed R&D/ Weapons Support	$5,348	$3,140	$3,177	$2,945	$4,781
Capital Equipment	$1,423	$1,193	$482	$90	$215
	$65,747	**$62,866**	**$61,453**	**$63,935**	**$61,327**

Engineering Staffing Profile-9/30/97

	Total	Career	Term	Other Labor
100 Series-Administrative	37	36	1	0
200 Series-Engineer	737	645	35	57
300 Series-Supv./Associate	364	342	6	16
400 Series-Clerical	96	79	10	7
500 Series-Technician/Draft	702	633	44	25
700 Series-Trainee	8	0	0	8
900 Series-Machinist	135	135	0	0
TOTAL	**2,079**	**1,870**	**96**	**113**

Note: Other Labor includes Indeterminates and Retirees

FY97 Manpower Changes (FTEs)

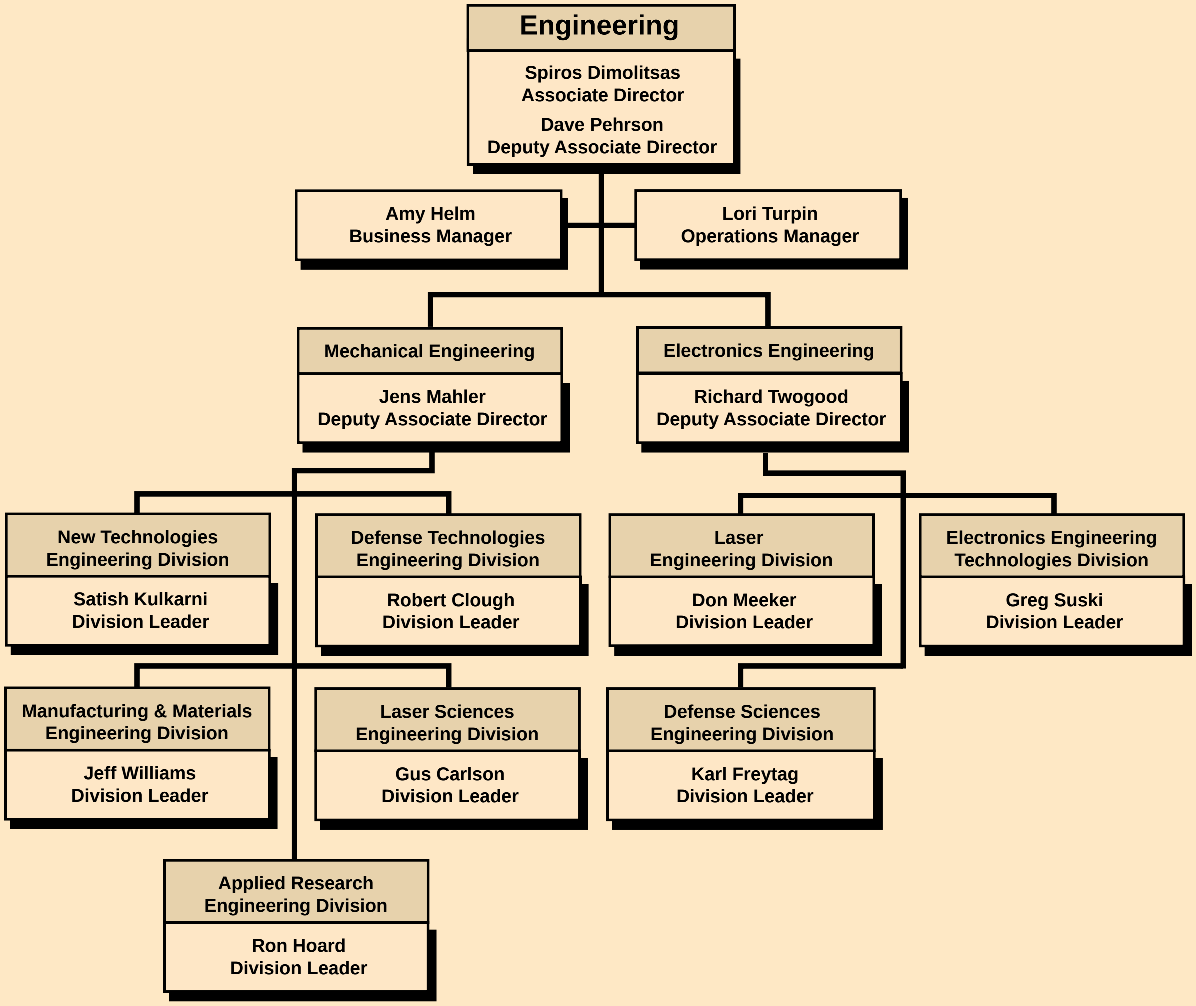
Directorate	Oct. 96	Sep. 97	Delta	% Change
Biology & Biotechnology Research (B&BR)	12.4	12.5	0.1	0.8%
Chemistry & Materials Science (C&MS)	22.7	24.3	1.6	7.0%
Computation	32	40.6	8.6	26.9%
Defense & Nuclear Technologies (D&NT)	468.5	486.7	18.2	3.9%
Deputy Director for Science & Technology (DDS&T)	17.5	16.1	-1.4	-8.0%
Energy	105.4	111.3	5.9	5.6%
Engineering	301.5	321.2	19.7	6.5%
Earth & Environmental Sciences (EE&S)	30.4	22.8	-7.6	-25.0%
Lasers	617.2	600	-17.2	-2.8%
Nonproliferation, Arms Control & Int'l Security (NAI)	125.1	118.6	-6.5	-5.2%
Physics & Space Technology (P&ST)	115.1	100	-15.1	-13.1%
Plant Operations	84.7	59.1	-25.6	-30.2%
Other	13.1	17.4	4.3	32.8%
TOTAL FTEs	**1945.6**	**1971.8**	**26.2**	**1.3%**

Engineering Workforce Changes-9/30/97

	External Hires		Transfers In		Terminations		Retired		Transfers Out	
	Career	Non	Career	Non	Career	Non	Career	Non	Career	Non
100	0	0	3	0	1	0	1	0	1	0
200	34	29	16	1	30	14	8	0	6	2
300	0	6	1	0	13	5	22	0	5	1
400	0	0	8	5	0	7	1	0	13	7
500	3	44	12	0	24	8	6	0	11	0
900	0	0	0	0	2	0	0	0	2	0
700 (OJT)	0	6	0	6	0	1	0	0	0	6
TOTALS	**37**	**85**	**40**	**12**	**70**	**35**	**38**	**0**	**38**	**16**

Note: Non-Careers are Indeterminate, Fixed-Term/Temps, Summers, and Retirees

Engineering Senior Management-9/30/97



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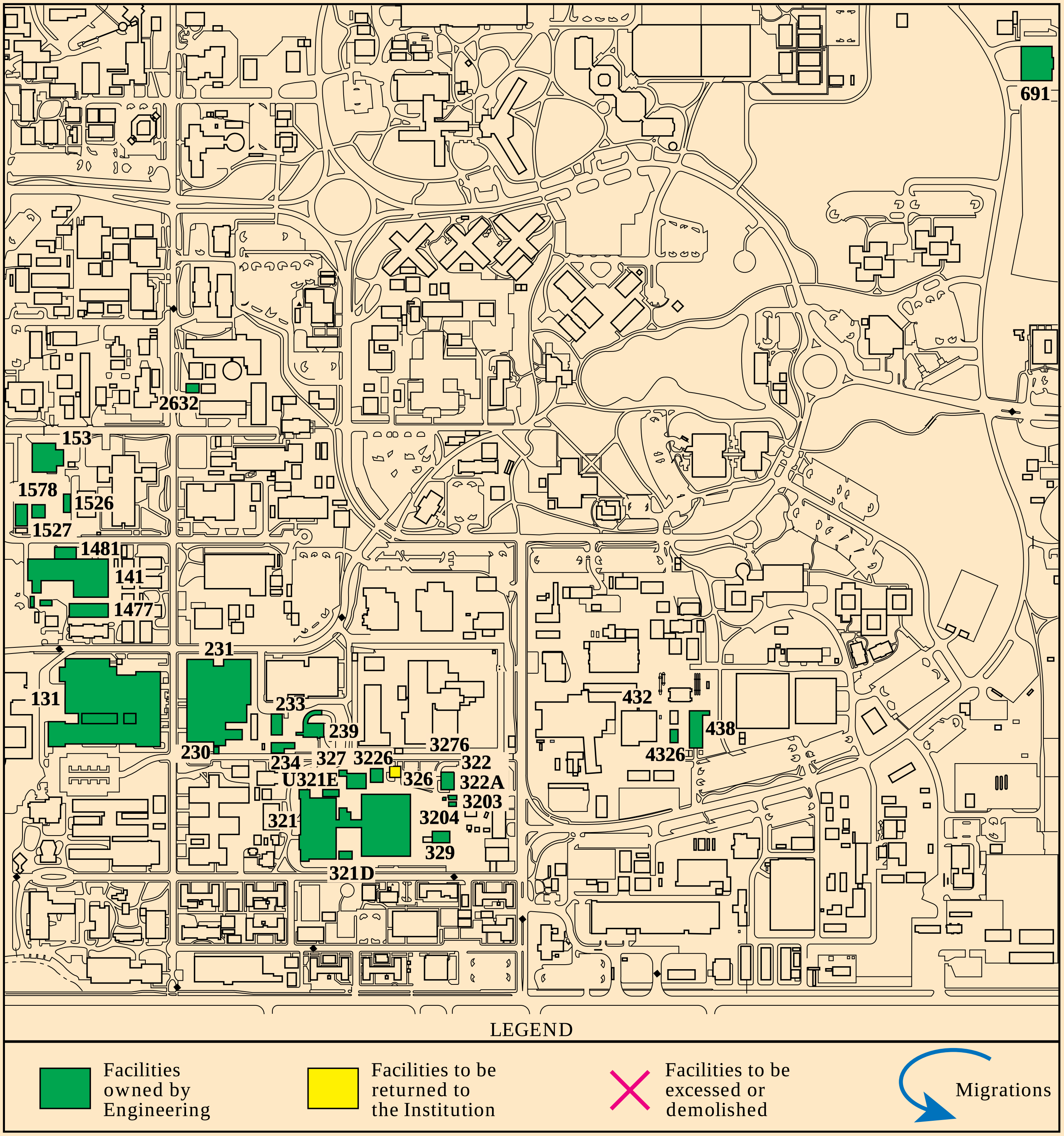
Engineering Facility Changes-9/30/97



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Core Values

Workforce

Accomplishments

Challenges